Kevin Peter Hand, Ph.D. March 2020

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Current Position

- Pre-Project Scientist, Pre-Phase A Europa Lander Mission Concept
- PI/Director, Ocean Worlds Lab, JPL. https://oceanworldslab.jpl.nasa.gov/
- Planetary Scientist/Astrobiologist, Jet Propulsion Laboratory
- Adjunct Research Scientist, Woods Hole Oceanographic Institution, Woods Hole, MA.

Biography

Kevin P. Hand is a planetary scientist/astrobiologist at JPL working on numerical modeling and laboratory investigations concerning the physics and chemistry of icy moons and ocean worlds in the outer solar system. His specialty in the laboratory is the cryogenic spectroscopy and spectrometry of radiation processed ices that simulate the surfaces of ice-covered moons of the outer solar system.

Dr. Hand is Project Scientist for the Europa Lander mission, which is currently in Pre-Phase A development. He also served as Co-Chair of the 2016 Europa Lander Science Definition Team. Prior to these roles, he served as Deputy Chief Scientist for Solar System Exploration, where he helped guide JPL's future for the robotic exploration of our Solar System. Hand has worked closely with NASA Headquarters and educated members of congress about the value of basic research, climate change, and solar system exploration.

Dr. Hand served on the Science Definition Teams for Europa Flagship mission studies and has worked on several instruments for solar system exploration, including an active mid-infrared micro-Fourier Transform spectrometer that was field tested in Antarctica and proposed for the instrument suite on MSL. Hand served as the Science PI for the NASA Astrobiology Institute's 'Astrobiology of Icy Worlds' team based at JPL.

He has taught the physics and chemistry of planetary science and astrobiology at several 'short-courses', including: the NASA Astrobiology Institute's Santander Summer School (2008); the University of Hawaii's NAI Winter School (2011 & 2013); the 'Astrobiology of Icy Moons' Winter School at the Instituto de Astronomia, UNAM, Mexico City (2012); and Split University's (Croatia) Planetary Science Winter School (2008). He is also the founder of Cosmos Education, an international non-profit organization dedicated to grass-roots science education in developing regions of the world. He was a scientist onboard James Cameron's 2012 dive to the bottom of the Mariana Trench, and he was part of a 2003 expedition to hydrothermal vents in the Atlantic and Pacific oceans. He has made nine dives to the bottom of the ocean.

Education

Ph.D., Geological & Environmental Sciences, Stanford University, Stanford, CA. (2007)
Dissertation: 'On the physics and chemistry of the ice shell and sub-surface ocean of Europa'.
Advisor: C.F. Chyba

M.S., Mechanical Engineering, focus on robotics (2002), Stanford University, Stanford, CA.

B.A. Physics, with minor in Astronomy (1998), Dartmouth College, Hanover, New Hampshire.
Thesis: A Search for the Optical Counterpart to the Mysterious High-Latitude Transient X-ray Source, 4U0042+32.

Research Interests

- Icy moons and ocean worlds of the outer solar system
- Electromagnetic field interactions at icy worlds

- Radiolytic chemistry in planetary and astrophysical environments
- Spectroscopic biosignatures
- Understanding the connection between terrestrial cryosphere processes and the climate change record.

Funded Proposals

- NASA Astrobiology Institute Cycle 8 (now RCN, NNH17ZDA003C): Exploring Ocean Worlds: Ocean System Science to Support the Search for Life. PI: C. German, **Co-I K.P. Hand**. 2018-2022.
- NASA Scientific Exploration Subsurface Access Mechanism for Europa (SESAME): PROMETHEUS: nuclear-Powered RObotic MEchanism Technology for Hot-water Exploration of Under-ice Space. PI: B. Stone, **Co-I: K.P. Hand**. 2018-2021.
- NASA Cassini Data Analysis Program 2018-2020 (17-CDAP17_2-0046). *Investigating energetic electron weathering at Saturn's inner mid-sized moons*. **PI: K. Hand**, **Science-PI:** T. Nordheim (postdoc). ***Note***: My postdoc wrote this proposal and after he became a full scientist I transferred PI-ship to him. Award: $541K. **New PI: T. Nordheim (former postdoc)**.
- NASA Solar Systems Working 2018-2020 (16-SSW16_2-0195). *Volatile Adsorption on Irradiated Lunar Grain Surfaces*. **PI: K. Hand**, **Science-PI:** M. Poston (postdoc). ***Note***: My postdoc wrote this proposal and after he became a full scientist I transferred PI-ship to him. Award: $581K. **New PI: M. Poston. (former postdoc)**.
- NASA New Frontiers 4 Mission Call (17-NF4-0012). *Dragonfly*, *Quadcopter Mission to Titan*. PI: E. Turtle, **Co-I K.P. Hand**. Selected.
- NASA PICASSO (17-PICASO17_2-0123). *SLUSH: Thermo-Mechanical Deep Drilling System for Ocean Worlds and Mars.* PI: K. Zacny, **Co-I: K.P. Hand**.
- NASA PSTAR (17-PSTAR17_2-0024). *THOR - Thermal High-voltage Ocean-penetrator Research platform*. PI: W. Stone, **Co-I: K.P. Hand**.
- NASA PSTAR (15-PSTAR15_2-0033) 2016-2019, *Oases for life beneath ice-covered oceans: bio-signature pathways from seafloor ecosystems to the overlying ice-shell*. PI: C. German. **Co-I K.P. Hand**. Award: $2.46M.
- NASA Innovative Advanced Concepts (2016-2017) *Enceladus Vent Explorer Concept*. PI : Masahiro Ono. **Co-I : K.P. Hand**. Award: $120K.
- NASA PSTAR (16-PSTAR16_2-0027). *Multimodal Locomotion Enabling Ocean Worlds Science Operations.* PI: G.N. Meirion-Griffith, **Co-I: K.P. Hand**.
- NASA Europa Clipper Mission. Surface & Dust Analyzer for Europa (instrument selected for Europa Mission) PI: S. Kempf. **Co-I K.P. Hand**.
- NASA Cassini Data Analysis Program 2015-2018. *VIMS, INMS, and laboratory investigations of the carbon, nitrogen, and radiation chemistry of Saturn's icy moons*. **PI: K. Hand**, Award: $331K.
- NASA Instrument Concepts for Europa Exploration 2013-2014. *The Compositional Infrared Interferometric Spectrometer (CIRIS): A near- and mid-infrared Fourier transform spectrometer for investigations of the surface composition and habitability of Europa*. **PI: K. P. Hand**, Award: $1.2M.
- JPL Research & Technology Development 2010-13, *Fourier Transform Spectrometer for Primitive Bodies Investigation*. **PI: K. P. Hand**, Award: $550K.
- NASA ASTEP, Project Narvak: Arctic Lakes & Seasonal Cycles of Habitability. **PI: K. P. Hand**, Award (partially funded): $205K.
- NASA ASTID 2010, *Miniature Hyperspectral Laser Spectrometer Probe for Astrobiology*, PI: Nan Yu. **Co-I: K.P. Hand**.
- NASA Exobiology 2010, *Laboratory Investigation of the Workman-Reynolds Effect*, **PI: K.P. Hand**, Award: $300K.
- JPL Internal Advanced Concepts: *Europa Surface Science Package for EJSM*, **PI: K.P. Hand**, Award: $75K.

- NASA Astrobiology Institute-CAN5, *Astrobiology of Icy Worlds*. PI: I. Kanik, **Science PI: K.P. Hand**, Award: $8.5M.
- NASA PIDDP, *CIRIS A combined infrared interferometric spectrometer for compositional and thermal studies of moons, comets, and asteroids*. PI: R.W. Carlson. **Co-I: K.P. Hand**, Award: $450K.

Professional Experience

- Pre-Project Scientist, Europa Lander Mission concept (Pre-Phase A), May 2016-present.
- Co-Chair, 2016 NASA Europa Lander Science Definition Team
- Deputy Chief Scientist for Solar System Exploration (4x), JPL, Oct. 2011-May 2016.
- Scientist, Planetary Ices Group (3227), Jet Propulsion Laboratory, California Institute of Technology (Oct. 2007-Sept. 2011).
- Europa Flagship Mission Science Definition Team (2007, 2008, 2011, 2013 studies).
- Visiting Research Fellow, Dept. of Astrophysical Sciences, Princeton University (2006-2007).
- Geobiology Summer School, University of Southern California/Agoroun Institute. Catalina Island, CA. (June-July 2003).
- Research Assistant to C.F. Chyba, SETI Institute, (2000).
- Michelson Interferometry Summer School, NASA Jet Propulsion Laboratory/California Institute of Technology, Pasadena, CA. (July-August 1999).
- Research Assistant, Center for Mars Exploration, NASA Ames Res. Ctr. (1998-1999).
- Intern, Theoretical Astrophysics Division (TA-6), Los Alamos National Laboratory. Worked with S. Colgate on the late-time light curve of Type Ia Supernovae and on modeling plume convection in stellar atmospheres. (Spring 1995. Winter 1996)
- Research Assistant, Michigan-Dartmouth-MIT Observatory, Kitt Peak, AZ. Operated the 1.3 m reflector for 8 nights (Fall 1996).

Mission Related Work

- Pre-Project Scientist, Pre-Phase A Europa Lander Mission Concept
- Co-Chair, 2016 Europa Lander Science Definition Team
- Co-I *Surface Dust Mass Analyzer* (SUDA), *Europa Clipper* Mission
- Co-I *Dragonfly*, Titan Rotocopter, New Frontiers Mission
- Co-Chair Europa Clipper Habitability Working Group
- Mars Science Laboratory Wheel-Wear Tiger Team
- Project Scientist (Proposal) Discovery Class Mission, Journey to Enceladus and Titan (Discovery call 2011) *Not selected*.
- Deputy Project Scientist (Proposal) Discovery Class Mission, Proteus – mission to a water-rich main-belt asteroid. *Not selected.*
- Lead scientist for numerous JPL Europa Lander mission concepts studies over the 2009-2016 timeframe.

Awards

- JPL Explorer Award, for significant contributions to, and advancing, astrobiology and ocean worlds, 2016
- NASA Honors Award - Icy Worlds Team - Group Achievement Award (2015)
- NASA Honors Award - Group Achievement Award - MSL Prime Mission Science and Operations Team, Wheel Wear Tiger Team (2015)
- NASA Honors Award - Team - Buoyant Rover for Under-Ice Exploration Team - Group Achievement Award (2014)
- National Geographic Society Emerging Explorer Award, 2011
- Lew Allen Award for Excellence, 2012
- Kavli Frontier of Science Fellow, 2007, 2011

Service

- Editorial Advisory Board, *Icarus*
- NRC Committee on Astrobiology & Planetary Sciences (2015-2017)
- United States Navy, Strategic Studies Group, Advisor/Lecturer, Nov. 2013
- X-Prize Foundation, Advisory Council on Space and Exploration, 2013-present
- SETI Institute, Scientific Advisory Council, 2014-2016
- Rolex Foundation, Review Panel/Advisor, April 2014
- Advisor & subcommittee Co-Chair for National Academy Science & Entertainment Exchange program
- Reviewer for *Science*, *Nature*, *Icarus*, *Journal of Geophysical Research*, *ApJ*, *Planetary & Space Sciences*...
- Review panel member for NASA MDAP, CDAP, Exobiology, OPR, HOPE, RPS programs
- Member, Europa Science Definition Team 2008-2010, 2012-2013.
- Member: AGU, DPS.

Teaching Experience

Lecturer for 2014 University of Hawaii NASA Astrobiology Winter School, PI: Karen Meech. http://www.ifa.hawaii.edu/UHNAI/2014winterschool/
Lecturer for JPL's 2012 Mission Development Workshop, 2012. Lectured on *Observational Techniques & Strategies* to ~80 engineers and scientists.

Lecturer for the 2012 University of Mexico, 'Astrobiology of Icy Worlds' graduate and undergraduate student short-course. This course was held at the Universidad Nacional Autonoma de Mexico (UNAM) in Mexico City and was simultaneously broadcast to 7 other universities in Mexico and Spain. I gave 18 hours of lectures. Organizers: Dr. Antigona Segura Peralta, Irma Lozada Chavez, and L. C. Delgado.

Lecturer for 2011 University of Hawaii NASA Astrobiology Winter School, PI: Karen Meech. http://www.ifa.hawaii.edu/UHNAI/2011winterschool/

Lecturer for 2008 NASA Astrobiology Institute 'Josep Comas I Sola' International Summer School on 'The Astrobiology of Icy Worlds', Santander, Spain. http://nai.arc.nasa.gov/uimp/IcyWorlds/

Lecturer for Split University two-week "International Winter School on Astrobiology and Extrasolar Planets". Split, Croatia. Feb-March 2007 and 2008. (http://fizika.pmfst.hr/astro/english/astrobiologija.html)

Stanford: "GES 51: Undergraduate seminar on the Origin and Evolution of the Universe" (Spring 2004) Teaching assistant for Professor Mike McWilliams. Responsibilities included giving many lectures, advising on research topics, and grading term papers. Also coordinated a class field trip to several locales in Southern California, including a visit to JPL. Class size: ~15.

Stanford: "GES 2: Earth System History" (Winter 2003/2004) Teaching assistant for Professor Mike McWilliams. Responsibilities included giving several lectures, grading, and running lab sessions and field trips. Class size: ~60 students.

Stanford: "Geological & Environmental Sciences (GES) 1: Dynamic Earth: Fundamentals of Earth Science" (Spring 2003) Teaching assistant for Professor Page Chamberlain. Responsibilities included giving several lectures, grading, and running lab sessions and field trips. Class size: ~60 students.

Stanford: "GES 2: Earth System History" (Winter 2002/2003) Teaching assistant for Professor Page Chamberlain. Responsibilities included giving lectures, grading, and running lab sessions and field trips. Class size: ~60 students.

Stanford: "GES 7: An Introduction to Wilderness Skills" (2002-2003) Instructor for course taught through the Geological & Environmental Sciences department. Course covers everything from camping basics to avalanche danger and technical climbing skills. Originally designed to prepare students for fieldwork. Responsibilities included classroom lectures and weekend trips to the Sierra. Class size: ~10 students.

Santa Clara University: "Introduction to the Solar System" (Spring 1999) Guest lectured for two weeks, covering the terrestrial planets. Class size: ~40 students.

Dartmouth: "Astrophysics 15, Introduction to Astrophysics" (1997) Teaching assistant for Professor John Thorstensen. Responsibilities included grading problem sets and running observation sessions at the on-campus observatory (9.1 inch refractor). Class size: ~15 students.

Dartmouth: "Astronomy 3, Introduction to Astronomy", (TA'd on several occasions between 1995-1997). Teaching assistant for Professors R. Fesen, J. Thorstensen, and G. Wegner. Responsibilities included grading homework and exams, and running observation sessions at the on-campus observatory (9.1 inch refractor). Class size: ~80 students.

Publications

Journals

Hand, K.P., Bartlett, D. H., Fryer, P., Peoples, L., Williford, K., Hofmann, A. E., & Cameron, J. (2020). Discovery of novel structures at 10.7 km depth in the Mariana Trench may reveal chemolithoautotrophic microbial communities. *Deep Sea Research Part I: Oceanographic Research Papers*, 103238.

Hand, K.P., Berisford, D., Daimaru, T., Foster, J., Hofmann, A. E., & Furst, B. (2020). Penitente formation is unlikely on Europa. *Nature Geoscience*, 13(1), 17-19.

Nordheim, T. A., Jasinski, J. M., & **Hand, K. P.** (2019). Galactic Cosmic-Ray Bombardment of Europa's Surface. *The Astrophysical Journal Letters*, 881(2), L29.

Trumbo, S. K., Brown, M. E., & **Hand, K. P.** (2019). H_2O_2 within Chaos Terrain on Europa's Leading Hemisphere. *The Astronomical Journal*, 158(3), 127.

Trumbo, S. K., Brown, M.E. & **Hand K.P.** (2019) Sodium chloride on the surface of Europa. *Science Advances*. 5(6), eaaw7123.

Santibáñez, P. A., Michaud, A. B., Vick-Majors, T. J., D'Andrilli, J., Chiuchiolo, A., **Hand, K. P.**, & Priscu, J. C. (2019). Differential Incorporation of Bacteria, Organic Matter, and Inorganic Ions into Lake Ice during Ice Formation. *Journal of Geophysical Research: Biogeosciences*.

Ward, L. M., Stamenković, V., **Hand K.P.**, & Fischer, W. W. (2019) Follow the Oxygen: Comparative Histories of Planetary Oxygenation and Opportunities for Aerobic Life. Astrobiology 1531-1074.

Young, C. L., Poston, M. J., Wray, J. J., **Hand, K. P.**, & Carlson, R. W. (2018). The mid-IR spectral effects of darkening agents and porosity on the silicate surface features of airless bodies. *Icarus*. 321:71-81.

Nordheim, T. A., **Hand, K. P.**, & Paranicas, C. (2018). Preservation of potential biosignatures in the shallow subsurface of Europa. *Nature Astronomy*, *2*(8), 673.

Carnevali, P. B. M., Herbold, C. W., **Hand, K.P.**, Priscu, J. C., & Murray, A. E. (2018). Distinct Microbial Assemblage Structure And Archaeal Diversity In Sediments Of Arctic Thermokarst Lakes Differing In

Methane Sources. *Frontiers in Microbiology*, 9.

Hand, K. P., German, C. R. (2018) Exploring ocean worlds on Earth and beyond. *Nature Geoscience*. Vol. 11:1.

Poston MJ , Mahjoub A, Ehlmann BL, Blacksberg J, Brown ME, Carlson RW , Eiler JM, **Hand KP**, Hodyss R, & Wong I. (2018) Visible near-infrared spectral evolution of irradiated mixed ices and application to Kuiper Belt Objects and Jupiter Trojans. *The Astrophysical Journal.* 856:124.

Poston, M. J., Carlson, R. W., **Hand, K.P.** (2017) Spectral Behavior of Irradiated Sodium Chloride Crystals Under Europa-Like Conditions. *Journal of Geophysical Res. – Planets*. Vol. 122:12, 2644-2654.

Russell, M. J., Murray, A. E., **Hand, K. P.** (2017) The Possible Emergence of Life and Differentiation of a Shallow Biosphere on Irradiated Icy Worlds: The Example of Europa. *Astrobiology*. Vol. 17:12, 1265-1273.

Mahjoub, A., Poston, M.J., Blacksberg, J., Eiler, J.M., Brown, M.E., Ehlmann, B.L., Hodyss, R., **Hand, K.P.**, Carlson, R. and Choukroun, M. (2017). Production of Sulfur Allotropes in Electron Irradiated Jupiter Trojans Ice Analogs. *Astrophysical Journal*, *846*(2).

Trumbo, S. K., Brown, M. E., Fischer, P. D., & **Hand, K. P.** (2017). A New Spectral Feature on the Trailing Hemisphere of Europa at 3.78 μm. *The Astronomical Journal*, *153*(6), 250.

Nordheim, T. A., **Hand, K. P.**, Paranicas, C., Howett, C. J. A., Hendrix, A. R., Jones, G. H., & Coates, A. J. (2017). The near-surface electron radiation environment of Saturn's moon Mimas. *Icarus*.

Sparks, W. B., Schmidt, B. E., McGrath, M. A., **Hand, K. P.**, Spencer, J. R., Cracraft, M., & Deustua, S. E. (2017). Active Cryovolcanism on Europa?. *The Astrophysical Journal Letters*, *839*(2), L18.

Fischer, P. D., Brown, M. E., Trumbo, S. K., & **Hand, K. P.** (2016). Spatially resolved spectroscopy of Europa's large-scale compositional units at 3-4 μm with Keck NIRSPEC. *The Astronomical Journal*, *153*(1), 13.

Chyba, C. F., & **Hand, K. P.** (2016). Electric Power Generation from Earth's Rotation through its Own Magnetic Field. *Physical Review Applied*, *6*(1), 014017.

Vance, S. D., **Hand, K. P.**, & Pappalardo, R. T. (2016). Geophysical controls of chemical disequilibria in Europa. *Geophysical Research Letters*, *43*(10), 4871-4879.

Sparks, W. B., **Hand, K. P.**, McGrath, M. A., Bergeron, E., Cracraft, M., & Deustua, S. E. (2016). Probing for evidence of plumes on europa with HST/STIS. *The Astrophysical Journal*, *829*(2), 121.

Mahjoub, A., Poston, M. J., **Hand, K. P**., Brown, M. E., Hodyss, R., Blacksberg, J., Eiler, J. M., Carlson, R. W., Ehlmann, B. L., Choukroun, M. (2016). Electron Irradiation and Thermal Processing of Mixed-ices of Potential Relevance to Jupiter Trojan Asteroids. The Astrophysical Journal, 820(2), 141.

Fischer, P. D., Brown, M. E., **Hand, K. P.** (2015) Spatially Resolved Spectroscopy of Europa: The Distinct Spectrum of Large-scale Chaos. The Astronomical Journal.

Young, C.L., Wray, J. J., Clark, R. N., Spencer, J. R., Jennings, D. E., **Hand**, **K. P.,** Poston, M. J. and Carlson, R. W. (2015) Silicates on Iapetus from Cassini's Composite Infrared Spectrometer. *Astrophys. J. Lett. 811*, L27.

Carlson, R.W. and **Hand, K.P**. (2015) Radiation Noise Effects at Jupiter's Moon Europa:
In-situ and Laboratory Measurements and Radiation Transport Calculations. *Transactions on Nuclear Science*. 62, 5, 2273-2282.

Hand, K.P., and Carlson, R.W (2015) Europa's surface color indicates an ocean rich with sodium chloride. *Geophys. Res. Lttrs*., 42, 3174-3178.

Matheus Carnevali, P., Rohrssen, M., Williams, M.R., Michaud, B., Adams, H., Berisford, D., Love, G.D., Priscu, J.C., Rassuchine, O., **Hand, K.P**., Muray, A.E. (2015) Methane sources in arctic thermokarst lake sediments on the North Slope of Alaska. *Geobiology*. doi: 10.1111/gbi.12124.

Chyba, C.F., **Hand, K.P**., and Thomas, P.C. (2015) Energy Conservation and Poynting's Theorem in the Homopolar Generator. *Am. J. Phys.* **83** (1).

Paranicas, C., Roussos, E., Decker, R.B., Johnson, R.E., Hendrix, A.R., Schenk, P., Cassidy, T.A., Dalton III, J.B., Howett, C.J.A., Kollmann, P., Patterson, W., **Hand, K.P**., Nordheim, T.A., Krupp, N., Mitchell, D.G. (2014) The lens feature on the inner saturnian satellites, Icarus, Volume 234, 155-161, ISSN 0019-1035.

Pappalardo, R.T., Vance, S., Bagenal, F., Bills, B.G., Blaney, D.L., Blankenship, D.D., Brinckerhoff, W.B., Connerney, J.E.P., **Hand, K.P**., Hoehler, T.M., Leisner, J.S., Kurth, W.S., McGrath, M.A., Mellon, M.T., Moore, J.M., Patterson, G.W., Prockter, L.M., Senske, D.A., Schmidt, B.E., Shock, E.L., Smith, D.E., and Soderlund, K.M. (2013) Science Potential from a Europa Lander. Astrobiology. 13(8): 740-773. doi:10.1089/ast.2013.1003.

Hand, K.P. and Brown, M.E. (2013) Keck II Observations of Hemispherical Differences in H_2O_2 on Europa. The Astrophysical Journal Letters, 766:2, L21, doi:10.1088/2041-8205/766/2/L21.

Brown, M.E. and **Hand, K.P.** (2013) Salts and Radiation Products on the Surface of Europa. The Astronomical Journal, 145:4, 110, doi:10.1088/0004-6256/145/4/110.

Lazcano, A. and **Hand, K.P**. (2012) Astrobiology: Frontier or fiction. Nature, Forum. 488, 7410, 160-161.

Liu, Y., Day, J. M. D., Ma, C., **Hand, K. P**., Pok, N. P., & Taylor, L. A. (2013). Chelyabinsk: An ordinary chondrite from a spectacular fall in Russia. Meteoritics and Planetary Science, 48(S1), A225.

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Boxe, C.S., **Hand, K.P.**, Nealson, K.H., Yung, Y.L., Yen, A.S., and Saiz-Lopez, A (2012) Adsorbed water and thin liquid films on Mars, International Journal of Astrobiology, 11, 3, 169-175, doi:10.1017/S1473550412000080.

Priscu, J. C. and **Hand, K.P.** (2012) Microbial Habitability of Icy Worlds. Microbe, 7:4, 167-172.

Wilson, J.P., Grotzinger, J.P., Fischer, W.W., **Hand, K.P.**, Jensen, S., Knoll, A.H., Abelson, J., Metz, J.M., McLoughlin, N., Cohen, P.A., Tice, M.M. (2012) Deep-Water Incised Valley Deposits at the Ediacaran-Cambrian Boundary in Southern Namibia Contain Abundant Treptichnus Pedum. *Palaios.* Vol. 27, 252-273.

Hand, K.P. and Carlson, R.W. (2012) Laboratory spectroscopic analyses of electron irradiated alkanes and alkenes in solar system ices J. Geophys. Res., 117, E03008, doi:10.1029/2011JE003888.

Hand, K.P. and Carlson, R.W. (2011) H_2O_2 production by high-energy electrons on icy satellites as a function of surface temperature and electron flux. Icarus. doi:10.1016/j.icarus.2011.06.031

Hand, K. P., K. K. Khurana, and C. F. Chyba (2011), Joule heating of the south polar terrain on Enceladus, J. Geophys. Res., 116, E04010, doi:10.1029/2010JE003776.

Korablev, O., Gerasimov, M., Dalton, J.B., **Hand, K.**, Lebreton, J-P., and Webster, C. (2011) Methods and measurements to assess physical and geochemical conditions at the surface of Europa, *Adv. Space Res.* doi:10.1016/j.asr.2010.12.010.

Sparks, W.B., McGrath, M., **Hand, K.P.,** Ford, H.C., Geissler, P., Hough, J.H., Turner, E.L., Chyba, C.F., Carlson, R., Turnbull, M. (2010) Hubble Space Telescope observations of Europa in and out of eclipse. Int. J. of Astrobiology 9(4):265-271.

Lorenz, R.D., Gleeson, D., Prieto-Ballesteros, Gomez, F., **Hand, K. P.**, Bulat, S. (2010) Analog Environments for a Europa Lander Mission. *Adv. in Space Research*, doi: 10.1016/j.asr.2010.05.006.

Clark, K., Boldt, J., Greeley, R., **Hand, K.P.**, Jun, I., Lock, R., Pappalardo, R.T., Van Houten, T., Yan, T. (2010) Return to Europa: Overview of the Jupiter Europa Orbiter Mission. *Adv. in Space Research*, doi:10.1016/j.asr.2010.04.011.

Cohen, P.A., Bradley, A., Knoll, A.H., Grotzinger, J.P., Jensen, S., Abelson, J., **Hand, K.**, Love, G., Metz, McLoughlin, N., Meister, P., Shepherd, R., Tice, M., Wilson, J.P. (2008) Tubular Compression Fossils from the Ediacaran Nama Group, Namibia. *Journal of Paleontology*.

Hand, K.P., Carlson, R. W., & Chyba, C. F. (2007) Energy, chemical disequilibrium, and geological constraints on Europa. *Astrobiology*. 7:6, 1-18.

Hand, K. P., & Chyba, C.F. (2007) Empirical constraints on the salinity of the europan ocean and implications for a thin ice shell. *Icarus*. 189:2, 424-438.

Hand, K. P., Carlson, R. W., Cooper, J., & Chyba, C. F. (2006) Clathrate hydrates of oxidants in the ice shell of Europa. *Astrobiology*. 6:3, 463-482.

Chyba, C. F. & **Hand, K. P**. Astrobiology: The Study of the Living Universe (2005) *Annual Reviews of Astronomy and Astrophysics*. 43:2.1-2.44.

Anderson, M.S., Andringa, J.M., Carlson, R.W., Conrad, P., Hartford, W., Shafer, M., Soto, A., Tsapin, A.I., Dybwad, J.P., Wadsworth, W., **Hand, K.P**. (2005) Fourier transform infrared spectroscopy for Mars science. *Review of Scientific Instruments*. 76: 034101.

McKay, C. P., **Hand, K. P**., Doran, P. T., Andersen, D. T. & Priscu, J. C. (2003) Clathrate formation and the fate of noble and biologically useful gases in Lake Vostok, Antarctica. *Geophys. Res. Lett.* Vol. 30, No. 13, 1702.

Zaitseva, L., and **Hand, K. P.** (2003) Nuclear Smuggling Chains: Suppliers, Intermediaries, and End-Users. *American Behavioral Scientist* 46:6, 822-844.

Chyba, C.F. and **Hand, K.P.** (2001) Life without Photosynthesis. *Science* 292, 2026-2027.

Book Chapters

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In addition, I have presented dozens of posters and talks at various DPS, AGU, NAI, etc. meetings

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Please email me for a separate document with contact information for references. Thank you.